

CHEM 9.5.6 THE SOLVAY PROCESS

The Solvay process has been in use since the 1860s

6.1 Identify the **raw materials used** in the **Solvay process** and name the **products**

- **Solvay Process:** production of **sodium carbonate**
- **Raw materials:**
 - **Brine** (saturated **NaCl** solution)
 - **Limestone** (calcium carbonate, **CaCO₃**)
 - **Ammonia** (**NH₃**)
- **Products:**
 - **Sodium Carbonate** (**Na₂CO₃**)
 - **Calcium Chloride** (**CaCl₂**)

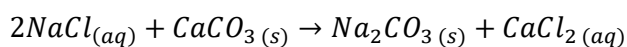
6.2 Describe the **uses** of sodium carbonate

- **Making glass** – sodium carbonate melted with **limestone and sand** and rapidly cooled
- **Softens hard water** – precipitates **Ca²⁺** and **Mg²⁺** ions
- **Alternative alkali to NaOH**
 - **Cheap** alkali, able to neutralise acid in factories, labs
 - Alternative base in **saponification**
- **Bleach paper**, making **NaHCO₃** for **baking soda and fire extinguishers**

6.3 identify, given a flow chart, the **sequence of steps used** in the Solvay process and describe the **chemistry** involved in:

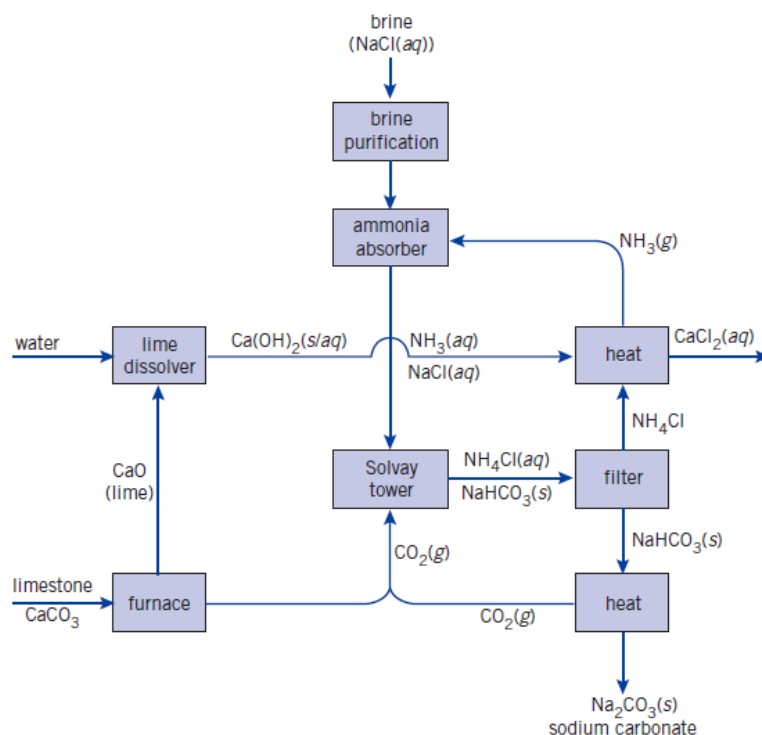
QUICK SUMMARY

1. Brine saturated with ammonia
2. CO₂ bubbled through to produce NaHCO₃
3. NaHCO₃ filtered and heated to form Na₂CO₃
4. Ammonia regenerated from filtrate



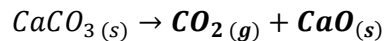
BRINE PURIFICATION

- Brine concentration increased to **30%**
- Brine from **sea water** is purified to remove **Mg²⁺** and **Ca²⁺** ions – **NaCO₃** and **NaOH** added to precipitate ions out
- **Flocculant** added and precipitates skimmed off
- **Limestone** is relatively pure

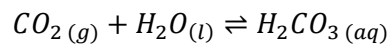


HYDROGEN CARBONATE FORMATION

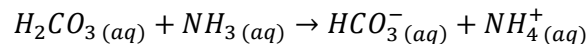
- **CaCO₃** placed in a **lime kiln**:



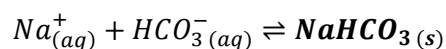
- Brine solution **saturated with ammonia** in **ammonia saturator/absorber**
- Solution fed into **carbonating tower**, cooled to 0°C and **CO₂ (from above) bubbled** into solution
 - CO₂ reacts with water:



- H₂CO₃ (carbonic acid) reacts with **ammonia** to form HCO₃⁻ and NH₄⁺ ions:



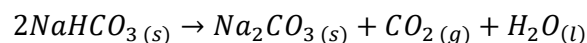
- Na⁺ ion from **NaCl reacts with HCO₃⁻ ion** to form **insoluble** precipitate (temperature 0°C)



- Therefore, in this section: $NaCl(aq) + CO_2(g) + H_2O(l) + NH_3(aq) \rightarrow NaHCO_3(s) + NH_4Cl(aq)$

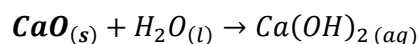
FORMATION OF SODIUM CARBONATE

- **NaHCO₃ filtered from solution** in carbonating tower, and **heated** to form **sodium carbonate**

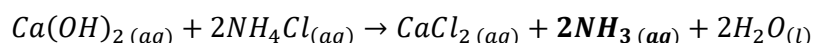


AMMONIA RECOVERY – PART OF THE SOLVAY PROCESS

- **Ammonia** – considered a **catalyst** as it is **not consumed** in the reaction and **allows the reaction to proceed**
 - Recovered as **ammonia is expensive**
- **CaO from lime kiln is slaked** (reacted with water), forming **calcium hydroxide (slaked lime)**



- NH₄Cl from carbonating tower residue is **reacted with calcium hydroxide** – releases ammonia



- Ammonia moved back to **ammonia absorber** with water, therefore **CaCl₂ is the only waste product**

6.4 Discuss **environmental issues** associated with the Solvay process and explain **how these issues are addressed**

- **Disposal of calcium chloride**: mainly disposed into oceans, not in
 - Neutralised by **bicarbonate (HCO₃)** in water, not suitable for **rivers/lakes** (Cl⁻ ions detrimental)
 - Sometimes **evaporated** to dryness **and buried underground**, but expensive
- **Loss of Ammonia** into the environment, is an **air pollutant**
- **Thermal pollution**: water used as a coolant for heat produced
 - Water is **cooled in cooling tanks** and discharged – cannot be directly released back into waterways
- **Mining** of limestone and brine can cause **environmental damage**